

Foundations of Semantic Web Technologies

Solutions for Exercise 6: SPARQL

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Solution (6.1).

- (a) Object which orbit around the sun or around a satellite of the sun.

```
PREFIX ex: <http://example.org/> .
SELECT ?object
WHERE {
    { ex:Sun ex:satellite ?object . } UNION
    { ex:Sun ex:satellite ?object_tmp .
      ?object_tmp ex:satellite ?object . }
}
```

- (b) Objects with a volume greater than 2×10^{10} (km³) together with the object – if it exists – of which they are a satellite.

```
PREFIX ex: <http://example.org/> .
SELECT ?object ?center
WHERE {
    { ?object ex:radius ?rad . }
    OPTIONAL { ?center ex:satellite ?object . }
    FILTER (4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)
}
```

- (c) Objects with a satellite for which an English name is given, and which furthermore are satellites of an object with diameter greater than 3000 (km).

```
PREFIX ex: <http://example.org/> .
SELECT ?object
WHERE {
    ?object          ex:satellite ?satellite .
    ?satellite      ex:name       ?name .
    ?center ex:satellite ?object .
    ?center ex:radius   ?rad .
}
```

```

        FILTER (langMATCHES (LANG(?name), "en"))
        FILTER (2*rad > 3000)
    }

```

- (d) Objects with two or more satellites. Assume for this that different URIs denote different objects.

```

PREFIX ex: <http://example.org/> .
SELECT ?object
WHERE {
    ?object ex:satellite ?satellit1 .
    ?object ex:satellite ?satellite2 .
    FILTER (!sameTerm(?satellit1, ?satellite2))
}

```

Solution (6.2). We do not expand IRIs to save space.

- (a) We only consider the query pattern:

```

{ ex:Sun ex:satellite ?object . } UNION
{ ex:Sun ex:satellite ?object_tmp .
  ?object_tmp ex:satellite ?object . }

```

The query pattern after replacing with BGPs:

```

{ Bgp(ex:Sun ex:satellite ?object .) } UNION
{ Bgp(ex:Sun ex:satellite ?object_tmp .
  ?object_tmp ex:satellite ?object .) }

```

Query pattern after replacing the UNION pattern:

```

Union(Bgp(ex:Sun ex:satellite ?object .),
      Bgp(ex:Sun ex:satellite ?object_tmp .
          ?object_tmp ex:satellite ?object .))

```

- (b) We consider only the query pattern:

```

{ ?object ex:radius ?rad . }
OPTIONAL { ?center ex:satellite ?object . }
FILTER (4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)

```

Pattern after replacing the BGPs:

```

Bgp(?object ex:radius ?rad)
OPTIONAL { Bgp(?center ex:satellite ?object) }
FILTER (4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)

```

Filter refer alway to the entire group, thus first the optional pattern:

```

LeftJoin(Bgp(?object ex:radius ?rad),
         Bgp(?center ex:satellite ?object),
         true)

```

```
FILTER (4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)
```

After replacing the filter:

```
Filter( (4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)
  LeftJoin( Bgp( ?object ex:radius ?rad),
    Bgp( ?center ex:satellite ?object),
    true)
)
```

(c) We consider only the query pattern:

```
?object ex:satellite ?satellite .
?satellite ex:name ?name .
?center ex:satellite ?object .
?center ex:radius ?rad .
FILTER (langMATCHES(LANG(?name), "en"))
FILTER (2*rad > 3000)
```

Query pattern after replacing the BGPs:

```
Bgp( ?object ex:satellite ?satellite .
  ?satellite ex:name ?name .
  ?center ex:satellite ?object .
  ?center ex:radius ?rad .)
FILTER (langMATCHES(LANG(?name), "en"))
FILTER (2*rad > 3000)
```

Filter conditions are the connected conjunctively:

```
Filter( (langMATCHES(LANG(?name), "en")) && (2*rad > 3000) ,
  Bgp( ?object ex:satellite ?satellite .
    ?satellite ex:name ?name .
    ?center ex:satellite ?object .
    ?center ex:radius ?rad .)
)
```

(d) We consider only the query patten:

```
?object ex:satellite ?satellit1 .
?object ex:satellite ?satellite2 .
FILTER (!sameTerm(?satellit1, ?satellite2))
```

Query pattern after replacing the BGPs:

```
Bgp( ?object ex:satellite ?satellit1 .
  ?object ex:satellite ?satellite2 .)
FILTER (!sameTerm(?satellit1, ?satellite2))
```

After replacing the filter:

```
Filter( (!sameTerm(?satellit1, ?satellite2)),
  Bgp( ?object ex:satellite ?satellit1 .
    ?object ex:satellite ?satellite2 .)
```

)

Solution (6.3).

(a) `Union(Bgp(ex:Sun ex:satellite ?object .),
Bgp(ex:Sun ex:satellite ?object_tmp .
?object_tmp ex:satellite ?object .))`

Evaluation of the BGP operators:

<u>object</u>	<u>object_tmp</u>	<u>object</u>
ex:Merkur	ex:Earth	ex:Moon
ex:Venus	ex:Mars	ex:Phobos
ex:Earth	ex:Mars	ex:Deimos
ex:Mars		

Evaluation of the Union operator:

<u>object_tmp</u>	<u>object</u>
ex:Earth	ex:Moon
ex:Mars	ex:Phobos
ex:Mars	ex:Deimos
	ex:Merkur
	ex:Venus
	ex:Earth
	ex:Mars

Since only object is selected, the column object_tmp is projected away.

(b) `Filter((4/3 * 3.1416 * ?rad * ?rad * ?rad > 20000000000)
LeftJoin(Bgp(?object ex:radius ?rad),
Bgp(?center ex:satellite ?object),
true)
)`

Evaluation of the BGP operators:

<u>object</u>	<u>rad</u>	<u>center</u>	<u>object</u>
ex:Sun	1.392e6	ex:Sun	ex:Merkur
ex:Merkur	2439.7	ex:Sun	ex:Venus
ex:Venus	6051.8	ex:Sun	ex:Earth
ex:Earth	6372.8	ex:Sun	ex:Mars
ex:Mars	3402.5	ex:Earth	ex:Moon
ex:Moon	1737.1	ex:Mars	ex:Phobos
		ex:Mars	ex:Deimos

Evaluation of the LeftJoin operator:

object	rad	mittelpunkt
ex:Sun	1.392e6	
ex:Merkur	2439.7	ex:Sun
ex:Venus	6051.8	ex:Sun
ex:Earth	6372.8	ex:Sun
ex:Mars	3402.5	ex:Sun
ex:Moon	1737.1	ex:Earth

Here, the filter does not filter any solutions. The column radius projected away.

```
(c) Filter( (langMATCHES(LANG(?name), "en")) && (2*rad>3000) ,
  Bgp(?object ex:satellite ?satellit .
    ?satellit ex:name ?name .
    ?center ex:satellite ?object .
    ?center ex:radius ?rad .)
)
```

Evaluation of the BGP operator:

center	rad	object	satellite	name
ex:Sun	1.392e6	ex:Earth	ex:Moon	"Moon@de"
ex:Sun	1.392e6	ex:Earth	ex:Moon	"Moon@en"
ex:Sun	1.392e6	ex:Mars	ex:Phobos	"Phobos"
ex:Sun	1.392e6	ex:Mars	ex:Deimos	"Deimos"

Evaluation of the filter:

center	rad	object	satellite	name
ex:Sun	1.392e6	ex:Earth	ex:Moon	"Moon@en"

Now, ex:Earth is returned as binding for object .

```
(d) Filter( (!sameTerm(?satellit1, ?satellite2)) ,
  Bgp(?object ex:satellite ?satellit1 .
    ?object ex:satellite ?satellite2 .)
)
```

Evaluation of the BGP operator:

object	satellite1	satellite2
ex:Sun	ex:Merkur	ex:Merkur
ex:Sun	ex:Merkur	ex:Venus
ex:Sun	ex:Merkur	ex:Earth
ex:Sun	ex:Merkur	ex:Mars
ex:Sun	ex:Venus	ex:Merkur
ex:Sun	ex:Venus	ex:Venus
ex:Sun	ex:Venus	ex:Earth
ex:Sun	ex:Venus	ex:Mars
ex:Sun	ex:Earth	ex:Merkur
ex:Sun	ex:Earth	ex:Venus
ex:Sun	ex:Earth	ex:Earth
ex:Sun	ex:Earth	ex:Mars
ex:Sun	ex:Mars	ex:Merkur
ex:Sun	ex:Mars	ex:Venus
ex:Sun	ex:Mars	ex:Earth
ex:Sun	ex:Mars	ex:Mars
ex:Sun	ex:Moon	ex:Moon
ex:Earth	ex:Moon	ex:Moon
ex:Mars	ex:Phobos	ex:Phobos
ex:Mars	ex:Phobos	ex:Deimos
ex:Mars	ex:Deimos	ex:Phobos
ex:Mars	ex:Deimos	ex:Deimos

After evaluating the filter:

object	satellite1	satellite2
ex:Sun	ex:Merkur	ex:Venus
ex:Sun	ex:Merkur	ex:Earth
ex:Sun	ex:Merkur	ex:Mars
ex:Sun	ex:Venus	ex:Merkur
ex:Sun	ex:Venus	ex:Earth
ex:Sun	ex:Venus	ex:Mars
ex:Sun	ex:Earth	ex:Merkur
ex:Sun	ex:Earth	ex:Venus
ex:Sun	ex:Earth	ex:Mars
ex:Sun	ex:Mars	ex:Merkur
ex:Sun	ex:Mars	ex:Venus
ex:Sun	ex:Mars	ex:Earth
ex:Mars	ex:Phobos	ex:Deimos
ex:Mars	ex:Deimos	ex:Phobos

Only the values of the column `object` are returned. Note that the binding `ex:Sun` occurs 12 times and the binding `ex:Mars` 2 times (bag instead of set semantic).

Solution (6.4).

```
@PREFIX ex: <http://example.org/> .
SELECT ?object
WHERE {
  ?object rdf:type ex:CelestialBody .
  OPTIONAL { ?object ex:satellite ?satellite. }
  FILTER (!BOUND(?satellite))
}
```

Solution (6.5). We assign the Sudoku cells as follows to variable names:

F11	F12	F13	F14
F21	F22	F23	F24
F31	F32	F33	F34
F41	F42	F43	F44

```
@PREFIX ex: <http://example.org/> .
SELECT ?F11 ?F12 ?F13 ?F14
      ?F21 ?F22 ?F23 ?F24
      ?F31 ?F32 ?F33 ?F34
      ?F41 ?F42 ?F43 ?F44
WHERE {
  ex:Cell ex:permits
    ?F11, ?F12, ?F13, ?F14,
    ?F21, ?F22, ?F23, ?F24,
    ?F31, ?F32, ?F33, ?F34,
    ?F41, ?F42, ?F43, ?F44 .
  FILTER( ?F14 = "3"^^xsd:int )
  FILTER( ?F24 = "4"^^xsd:int )
  FILTER( ?F31 = "2"^^xsd:int )
  FILTER( ?F41 = "3"^^xsd:int )
  FILTER( ?Fi != ?Fj )
}
```

Where the last filter is a placeholder, with

$$i, j \in \{11, 12, 13, 14, 21, 22, 23, 24, 31, 32, 33, 34, 41, 42, 43, 44\}, i \neq j.$$